



# NRL Use of IceBridge Sea Ice Products

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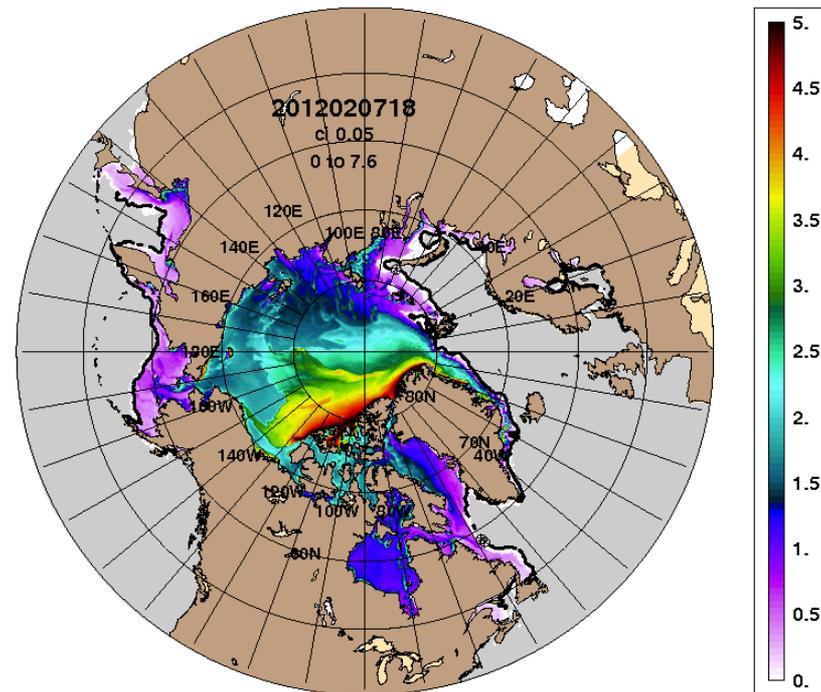
**Richard Allard, Pamela Posey**

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Naval Research Laboratory

Stennis Space Center, MS 39529

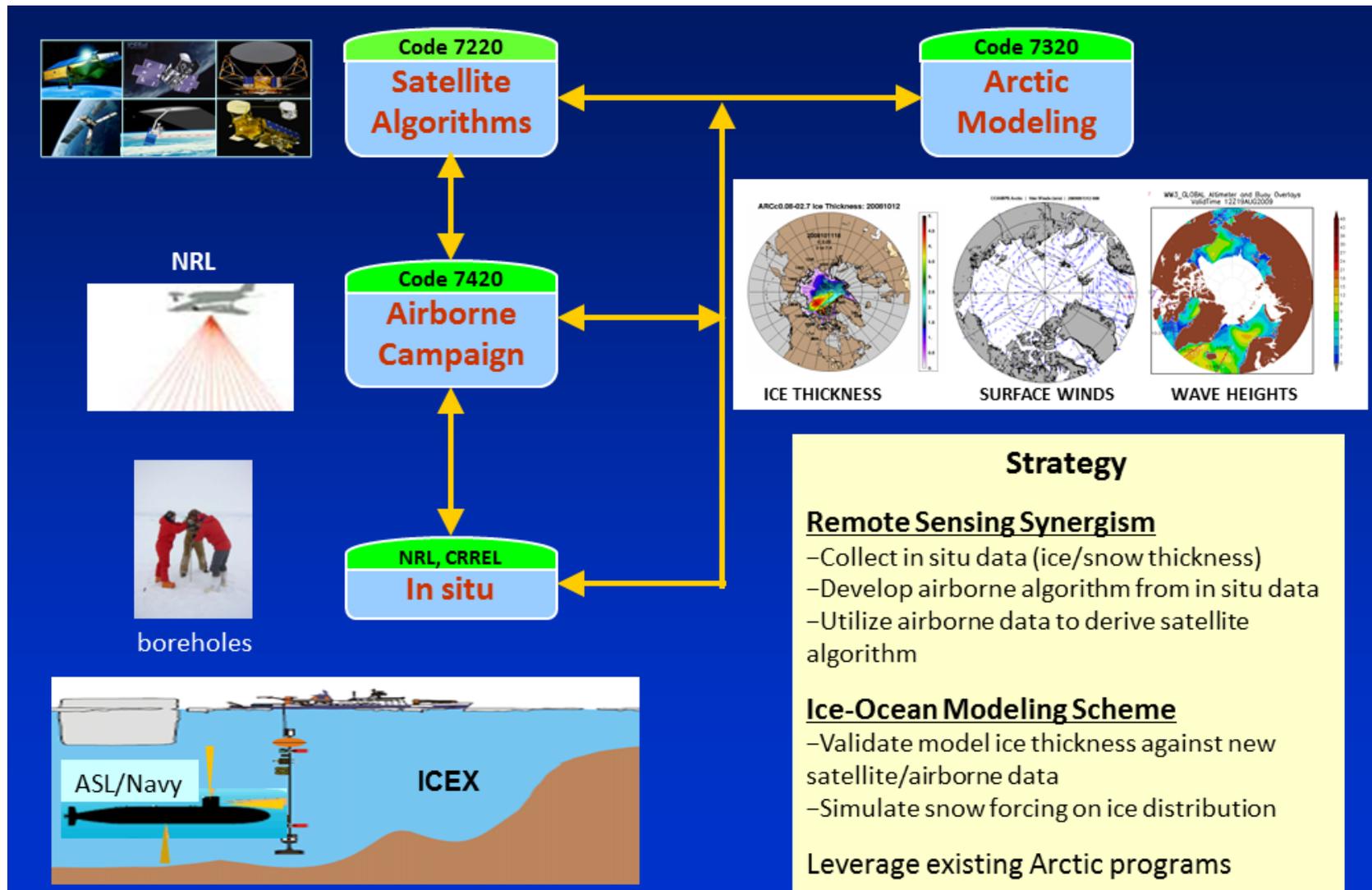
ARCc0.08-03.5 Ice Thickness: 20120205



IceBridge Science Team Meeting

January 2012, Goddard Space Flight Center, Greenbelt, MD

# NRL 6.1 Program: Determining the Impact of Sea Ice Thickness on the Arctic's Naturally Changing Environment (DISTANCE)



## Strategy

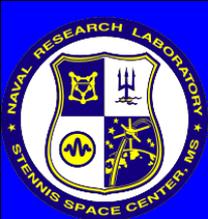
### Remote Sensing Synergism

- Collect in situ data (ice/snow thickness)
- Develop airborne algorithm from in situ data
- Utilize airborne data to derive satellite algorithm

### Ice-Ocean Modeling Scheme

- Validate model ice thickness against new satellite/airborne data
- Simulate snow forcing on ice distribution

Leverage existing Arctic programs



# NRL Use of IceBridge Sea Ice Products

- **NRL Arctic Cap Nowcast/Forecast System (ACNFS) ice model validation and IceBridge data assimilation (Rick Allard, Pamela Posey)**
  - Injected the IceBridge snow depth and ice thickness data into the data subsystem
  - Preliminary ACNFS and IceBridge data comparisons are encouraging
  - Working on assimilation of IceBridge ice thickness and snow data into ACNFS ice model
- **Coordinated airborne campaigns with OIB (John Brozena, Joan Gardner)**
  - ICEX 2010, 2011, 2012, 2013, **2014**
  - Use combined Lidar/Radar approach
  - Acquiring a snow radar from U Kansas (similar to what is flown on IceBridge)
- **Coordinated field work with OIB (Jackie Richter-Menge, Don Perovich)**
  - ICEX2011, **2014**
  - Snow depth and ice thickness, and Snow/ice surface roughness
  - Characterization of snow and ice vertical profiles
- **Sensor physics and snow/ice retrievals (Li Li, David Truesdale)**
  - Impacts of snow/ice/lead properties on radar/radiometer signatures
    - EM Model development and validation using NRL/CRREL and IceBridge data sets (ATM, Ku-band radar altimeter, DMS, CAMBOT, and snow depth).
  - Model up-scaling from airborne (NRL/IceBridge) to satellite (CryoSat-2/AMSR-2/WindSat) platforms

**Leveraging IceBridge Data is Essential for the Success of the DISTANCE Program**

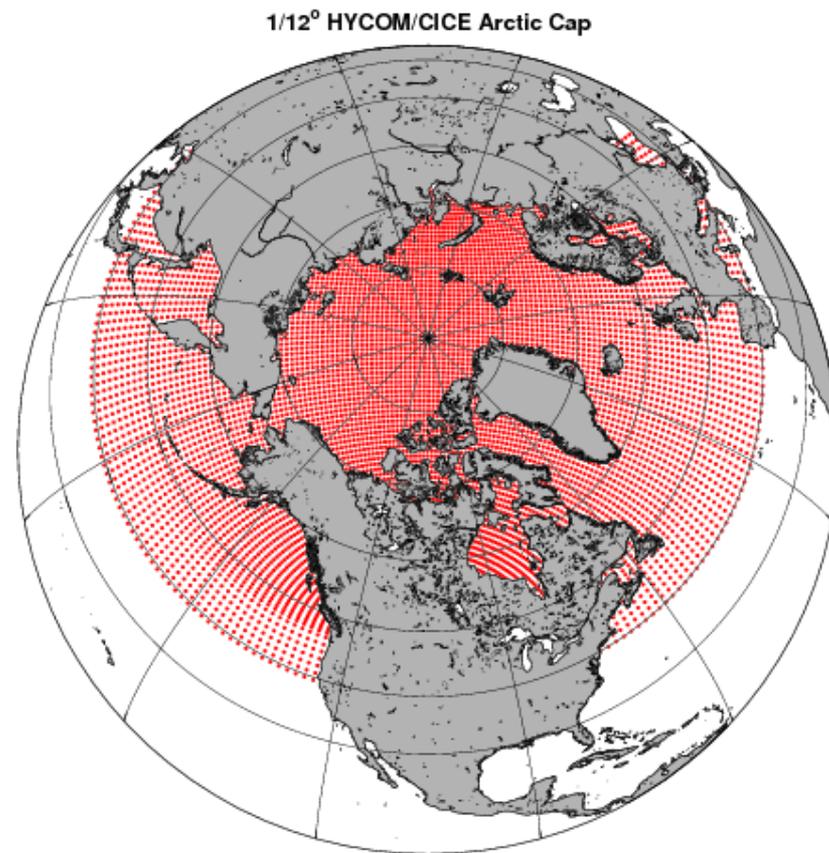


# NRL Arctic Cap Nowcast /Forecast System (ACNFS)



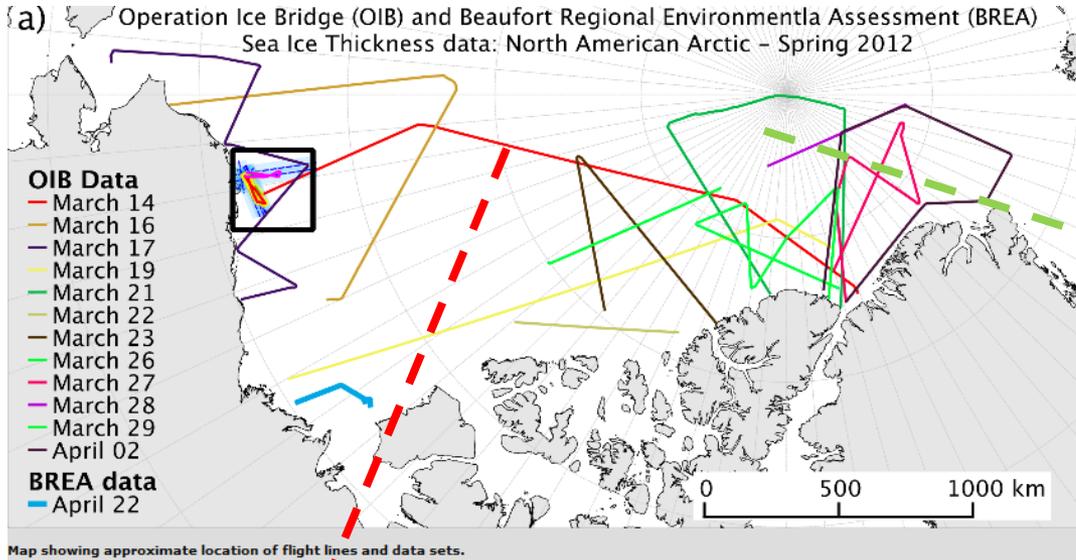
- A Coupled Sea Ice & Ocean Model
  - 1/12<sup>o</sup> (3.5 km at Pole) horizontal resolution
  - Ice Model (CICE)
  - Ocean Model (HYCOM)
    - » Receives boundary conditions from 1/12<sup>o</sup> global model
- Navy Coupled Ocean Data Assimilation (NCODA) System
- Data Products:
  - Ice thickness, ice concentration, ice speed and drift, sea surface height (SSH), sea surface temperature (SST) and sea surface salinity (SSS)

<http://www7320.nrlssc.navy.mil/hycomARC/>

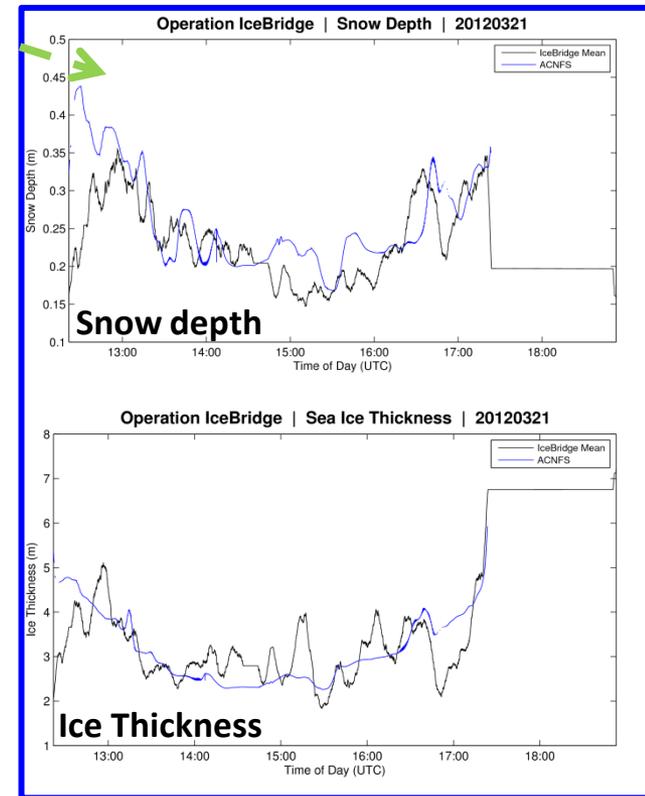


ACNFS model domain: every 20<sup>th</sup> grid point plotted

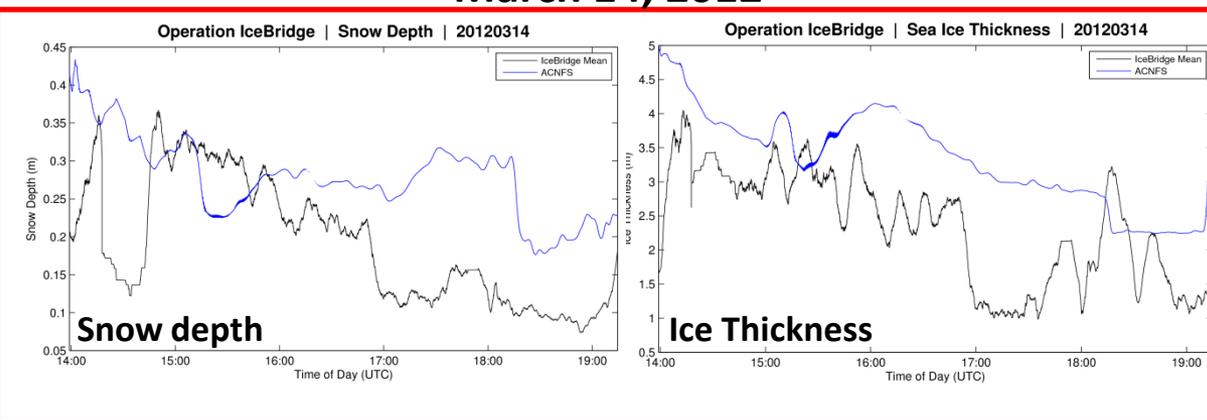
# Preliminary Examination of 2012 NASA IceBridge Data



**March 21, 2012**



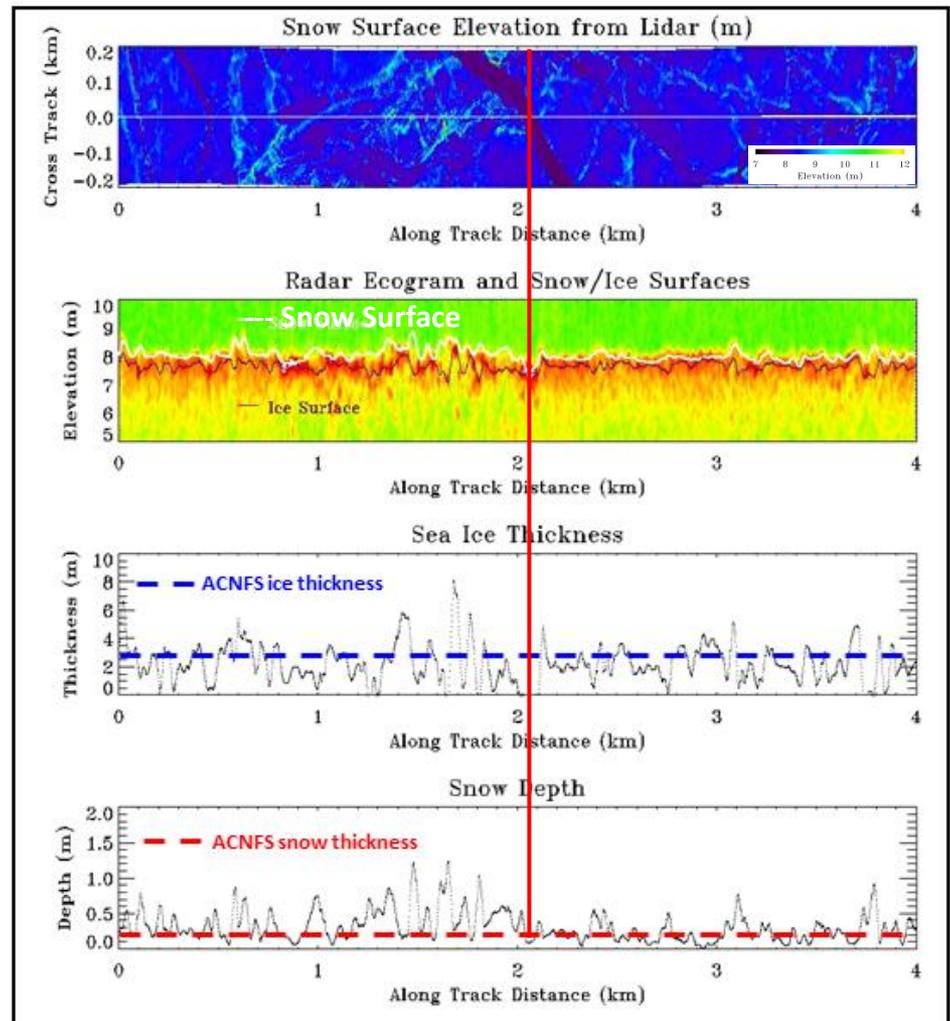
**March 14, 2012**



**Long Term Goal:** Ability to assimilate remotely sensed ice thickness and snow data into ice model

# Sea Ice Thickness and Snow depth Estimates Using NASA IceBridge Airborne Radar+LiDAR Data

- NRL has developed a preliminary combined laser/radar altimeter algorithm for retrieving sea ice thickness and snow-on-ice depth.
- First CryoSat-2 underflight flown by NASA IceBridge on 20 April 2010.
- [Top right panel](#) shows snow surface elevation measured by Airborne Topographic Mapper (ATM) LiDAR at 500m altitude.
- [Second panel](#) shows ku-band radar altimeter ecogram data at lower resolution (~16x10 m) to detect snow and ice surfaces.
- [Bottom panels](#) depict derived sea ice thickness and snow depth; ACNFS data shown as dashed line.

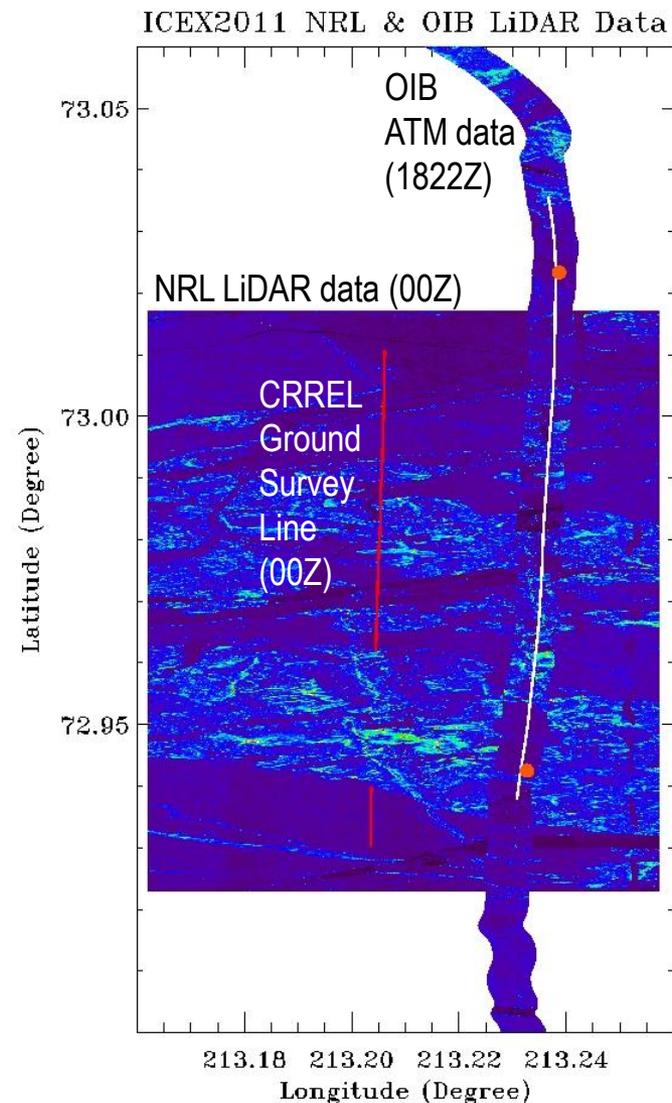


# CryoSat-2 Underflight by NRL & IceBridge (Mar 23, 2011)



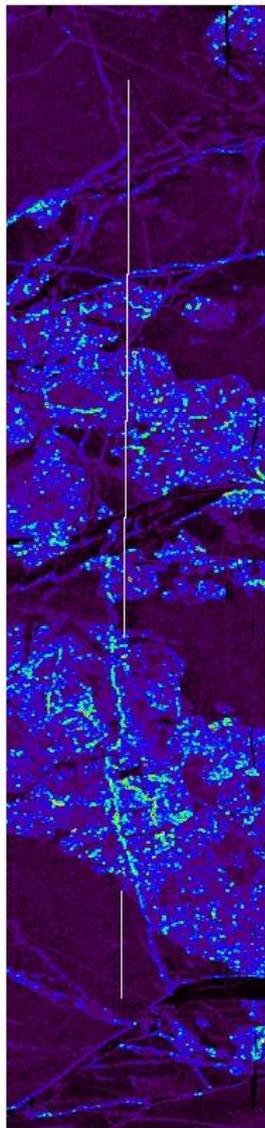
Geolocation derived  
from DMS data  
using Google Earth.  
Estimation error: 700m

- [Goal](#): Sensor signatures and their up-scaling from airborne to satellite.
- [NRL LiDAR](#): Snow surface roughness.
- [CRREL In Situ](#): Validation
- [OIB LiDAR/Radar](#): Data synergism.
- [OIB DMS/CAMBOT](#): Snow/ice characterization, geolocation.

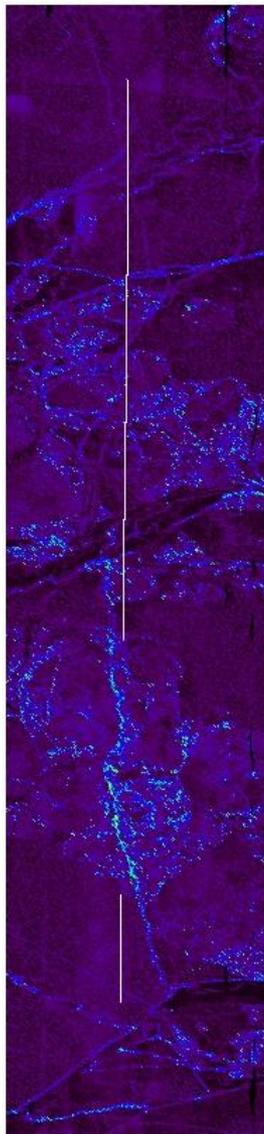


# NRL LiDAR Data Collection and Snow Surface Roughness (Mar 23, 2011)

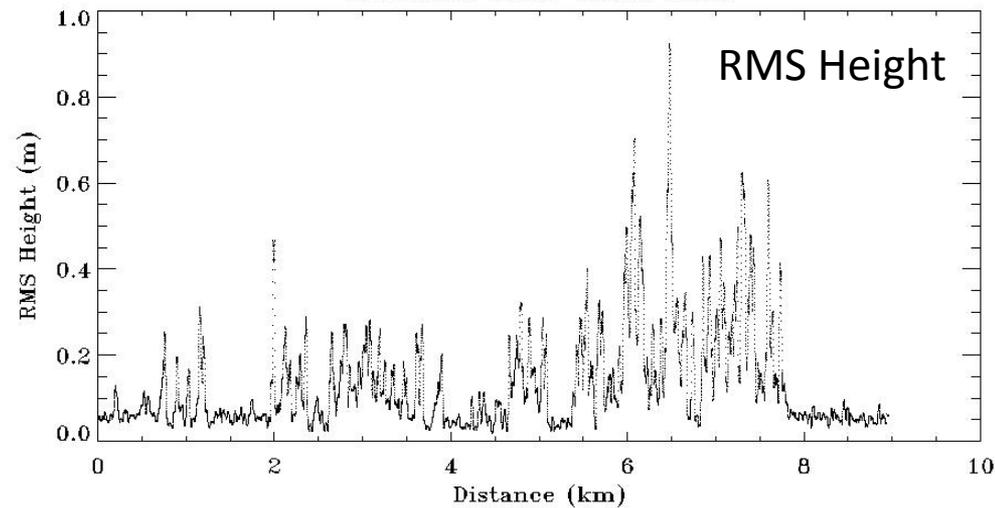
RMS Height



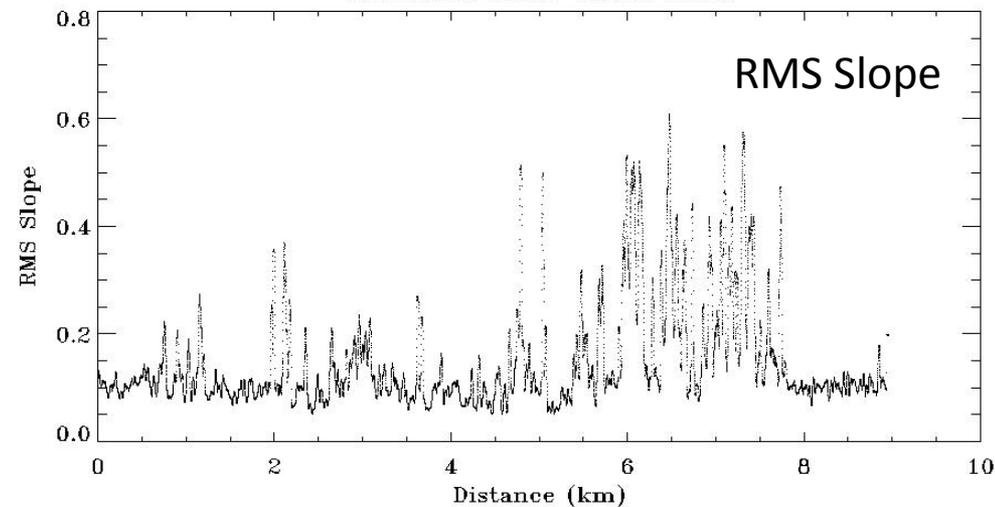
RMS Slope



NRL ICEX 2011 Lidar Data



NRL ICEX 2011 Lidar Data

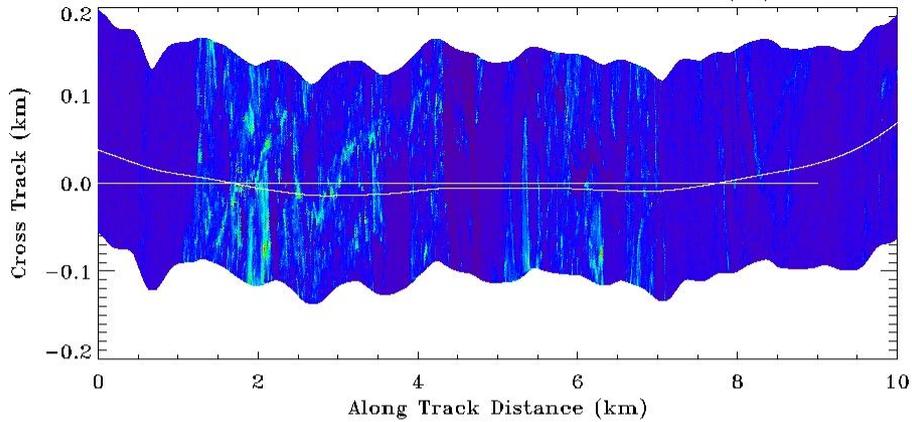




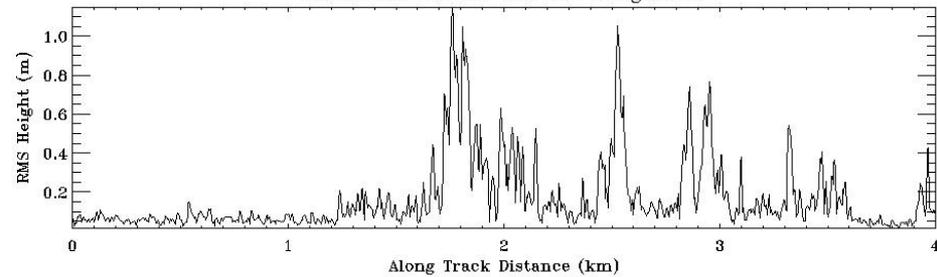
# IceBridge Combined Ku-Band Radar+ ATM Data



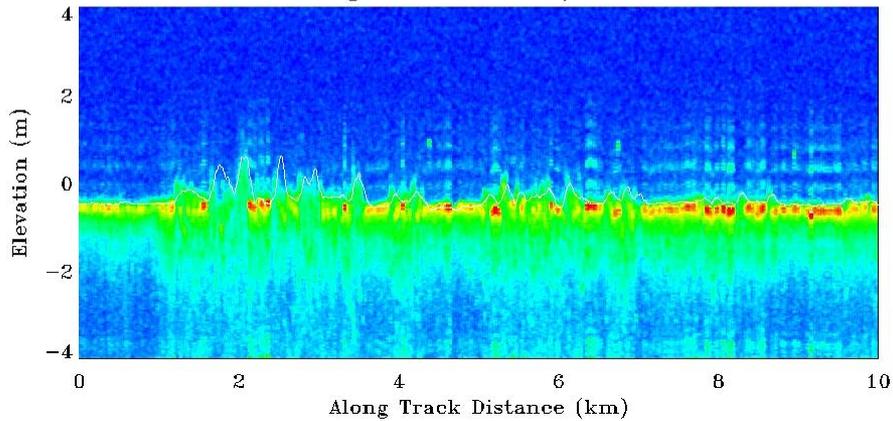
Snow Surface Elevation from Lidar (m)



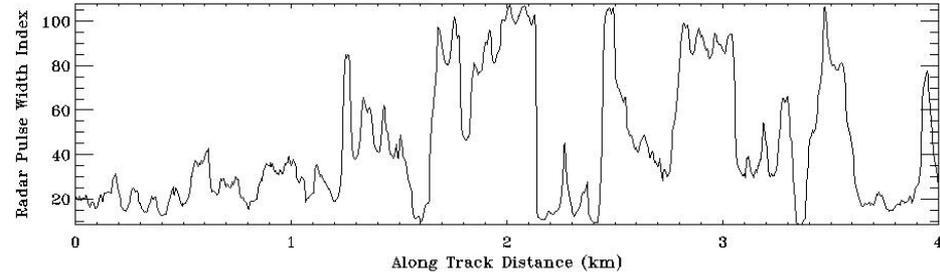
ATM Data Derived Surface Roughness



Radar Ecogram and Snow/Ice Surfaces



IceBridge Ku-Band Radar Echo



IceBridge Ku-Band Radar Echo

